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Evaluation of WRF modeling in relation to land surface schemes and initial and boundary conditions on a snow event and Parlung No. 4 Glacier simulations over the Tibetan Plateau

Lian Liu (1), Yaoming Ma (2), Massimo Menenti (3), and Weiqiang Ma (4)

(1) Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China (lliu@itpcas.ac.cn), (2) Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China (ymma@itpcas.ac.cn), (3) Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, China (M.Menenti@tudelft.nl), (4) Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China (wqma@itpcas.ac.cn)

Snowfall and the subsequent evolution of the snowpack play important roles in the cryospheric and hydrospheric processes which occur on the Tibetan Plateau (TP), where a wide range of mountain glaciers gather. Current literature provides scarce evidence covering the sensitivity of solid precipitation to land surface schemes and initial and boundary conditions on TP. Meteorological conditions in boundary layer i.e. near-surface air temperature (T2), wind speed (WS), radiations and precipitation which can be acquired from the Weather Research and Forecasting (WRF) model are essential in glacier surface energy and mass balance model. Therefore, it is necessary to evaluate WRF performance in relation to land surface schemes and initial and boundary conditions as well as glaciometeorological variables on TP glaciers.

Six numerical experiments using WRF were conducted to simulate a snow event over TP in March, 2017. Different land surface schemes (CLM, Noah, Noah-MP), and initial and boundary conditions provided by atmospheric reanalysis datasets (NCEP-FNL, ERA-Interim), were applied in sensitivity analyses. The results demonstrate that: (1) the sensitivity of T2 to land surface schemes is greater than to the initial and boundary conditions; (2) the best performance is achieved when applying WRF + CLM with a root mean square error (RMSE) 8.4°C , a correlation coefficient (CC) 0.75 and a spatial CC ~0.5 to T2 estimates. A potentially important factor appears to be the advanced albedo parametrization in CLM scheme; (3) simulations of solid precipitation are more accurate when applying CLM or Noah-MP + ERA-Interim in WRF although the intensity and extent of snow depth (SD) and snow water equivalent (SWE) are overestimated; and (4) WRF performance with regard to SWE estimates clearly depends upon the discrimination of lighter from heavier snowfall.

Two numerical experiments based on WRF were conducted on Parlung No. 4 Glacier in June 2016 with control experiment (EXP1) applying defaulted open shrublands surface type and sensitive experiment (EXP2) applying snow and ice surface type on the glacier. Some results are as follows: (1) the model has a capacity to achieve mean daily and diurnal variation of T2 on the glacier with best performance appearing when using actual land surface type, where the slope and intercept of linear regression equation are 1.08 and -0.01 respectively, and RMSE is 1.83°C with CC 0.81; (2) both experiments well acquire mean daily and diurnal fluctuation of WS with the modeled phase consistent with the observed one apart from largely underestimation of WS during daytime. The model gives lower RMSE 2.05 m s-1 with significant CC less than 0.4 when snow and ice surface type is applied; (3) The model greatly overestimates the precipitation during daytime; and (4) WRF performs well on diurnal variation and peak value of solar irradiance estimate with RMSE less than 234 W m-2 and CC more than 0.81, but performs bad on reflected shortwave radiation, which is related to unreasonable albedo parameterization scheme.